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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04B 7/185	A1	(11) International Publication Number: WO 97/15992 (43) International Publication Date: 1 May 1997 (01.05.97)

(21) International Application Number: PCT/IL96/00125

(22) International Filing Date: 10 October 1996 (10.10.96)

(30) Priority Data:

115787	27 October 1995 (27.10.95)	IL
08/660,075	3 June 1996 (03.06.96)	US

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(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

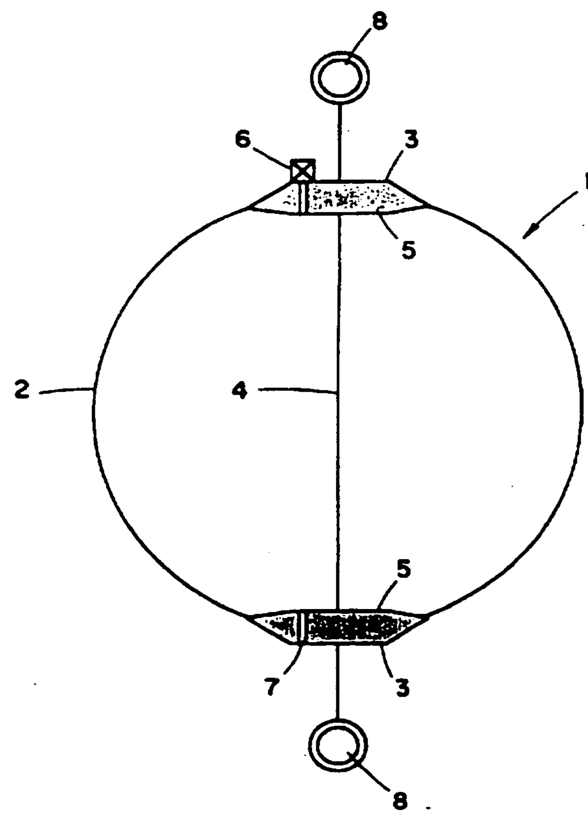
Published

With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: STRATO STATE PLATFORM AND ITS USE IN COMMUNICATION

(57) Abstract

A lighter-than-air platform capable of floating in the stratosphere. The platform carries a communication payload package and is fitted with an autonomous propulsion system for navigation and autonomously restoring the spatial position in case of deviations from a geo-stationary position. The energy requirements are met by electricity generators and during day time excessive electric power is stored for use at night. The platform is used as a communication link or for self-acquisition of data by a camera or a radar device.



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STRATO STATE PLATFORM AND ITS USE IN COMMUNICATION

FIELD OF THE INVENTION

The invention is in the field of communication and aims at providing a communication system with a stratospheric lighter–than–air platform fitted with a communication payload and serving as a wireless communication link (hereinafter occasionally referred to as "strato state platform" and for short SSP). The areas of applicability of the invention include, among others, cellular communication networks; mobile communication networks; radio and television cable broadcasting; pager systems; traffic control; earth resources survey; mapping; atmospheric research; remote detection of disasters such as sea contamination and forest fire, monitoring the evolution of hurricanes; monitoring atmospheric phenomena; monitoring agricultural conditions; detecting river floods; and there are many others.

BACKGROUND OF THE INVENTION AND PRIOR ART

There are known wireless communication links in form of geo–stationary satellites which orbit in space at high altitudes of thirty thousand kilometers and more. These systems have, among others, the drawback that the manufacture and launching of the satellites are very cumbersome and expensive, resulting in high service prices. Moreover, because of the large distance from the earth surface at which the communication satellites orbit, the RF beams which they emit cover very large areas which practically excludes some fields of application such as, for example, cellular telephone systems.

Accordingly, so-called land mobile satellite services (LMSS) have been under development for some time. In the LMSS systems the coverage and supply of wireless access lines is achieved by means of transponders and multi-beam antennas located on low earth orbit (LEO) satellites. The LEO satellites relay the RF energy of the terrestrial transmitter/receiver units assembled in a gateway station and beam it to the appropriate cells. However, the weight of the antenna array that can be mounted on an LEO satellite is limited which in combination with the still relatively high altitude (about 1,000 kilometers or even higher) at which they are designed to orbit, put limitations on the use thereof.

Flying balloons have been known for a very long time. In a balloon air buoyancy is provided by filling it with a gas that is lighter than the air in the surrounding atmosphere, such as, for example, hydrogen, helium or hot air. There are known so-called zero pressure balloons in which the inner pressure of the balloon is equal to that of the surrounding atmosphere, and so-called super pressure balloons in which the inner pressure exceeds that of the surrounding atmosphere by a few millibars.

It has been reported that flying balloons were launched to altitudes of as high as 30,000 - 40,000 meters. However, with known balloons the volume-to-payload ratio is very high so that for carrying the equipment and payload required for an SSP, the volume of a balloon has to be increased to an extent at which a naked balloon is difficult to manage. Also, known balloons drift in the wind and cannot be positioned in accordance with requirements, e.g. in a geo-stationary fashion.

GENERAL DESCRIPTION OF THE INVENTION

It is one object of the present invention to provide method and means of telecommunication with the use of essentially geo-stationary, lighter-than-air SSPs and suitably designed ground stations. It is a further object of the present invention to provide an energetically and navigationally autonomous lighter-than-air SSP, carrying a communication payload package.

In accordance with one aspect of the present invention there is provided a method of wireless telecommunication comprising floating in the stratosphere at a desired altitude at least one lighter-than-air strato state platform, which platform comprises an exoframe structure having an inner space holding at least one inflatable balloon mounted within said inner space and capable of being filled with and retain a lighter-than-air gas, a communication package including signal acquisition means and radio frequency (RF) energy transmission means, electric power generator means electric energy storage means, data acquisition means for providing altitude and spatial position data when the platform is airborne, navigation means responsive to said altitude and spatial data to control the location and position of the platform, and computer means for energy management and navigation; establishing at least one ground station capable of communicating with said lighter-than-air platform; and establishing a communication channel between at least one platform and a ground station.

The term "exoframe structure" as used herein signifies a framework whose inner space is capable of accommodating said at least one inflatable balloon.

The electric power generator means may be of any suitable kind such as for example, a fuel powered electricity generator or means for converting solar radiation into electric energy.

It has been found that, due to the relatively low altitude of the SSPs and their capability of carrying suitable antennas, a wireless telecommunication system according to the invention is superior to systems with conventional and LEO satellites in that the RF beams which it emits cover relatively small area cells whereby the number of subscribers may be increased while the cost of the platform and of its deployment is only a fraction of the costs in the case of satellites, whereby the service price is significantly lowered.

Depending on requirements, in the performance of the wireless telecommunication method according to the invention, an SSP may be so controlled as to be essentially geo-stationary or. alternatively, to move as

may be required. Where an SSP according to the invention is to move, this can be achieved autonomously in accordance with a program loaded into said computer means, or alternatively the movement may be controlled from a ground station.

Depending on the nature of the mission, the communication channel between the floating platform and the ground station may be uni-directional, i.e. only downlink, or bi-directional, i.e. uplink/downlink.

The term "signal acquisition" is used herein in a broad sense. Thus, by one mode of operation the signal acquisition means are designed to receive communication signals, e.g. radio or television transmission signals, which are relayed down to the ground station for transmission to subscribers, e.g. via a cable network. If desired, in this mode of operation two or more SSPs may be designed to communicate with each other.

By another mode the signals to be transmitted down to the ground station are processed from information acquired autonomously, e.g. images acquired by means of a camera or by a radar device, and the signals are transmitted to the ground station for the purpose of surveying or monitoring certain phenomena or events on the ground.

By yet another mode of performing the wireless telecommunication method according to the invention, a platform/ground station pair forms part of a bi-directional communication network such as, for example, a telephone network, which, if desired, may comprise a plurality of SSPs, and in this case the communication channel between the platform and ground station is bi-directional.

By another aspect of the invention there is provided in a wireless telecommunication system that includes at least one lighter-than-air airborne strato state platform floating at a suitable altitude, which platform comprises an exoframe structure (as herein defined) having an inner space holding at least one inflatable balloon mounted within said inner space and capable of being filled with and retain a lighter-than-air gas, a communication package including signal acquisition means and radio frequency (RF) energy transmission means, electric power generator means, electric energy storage

means, data acquisition means for providing altitude and spatial position data when the platform is airborne, navigation means responsive to said altitude and spatial position data to control the location and position of the platform and computer means for energy management and navigation; a ground station; and a communication channel between said lighter-than-air platform and ground station.

The suitable floating altitude of an SSP in a communication system according to the invention is as a rule selected to be an altitude at which in a wind/altitude profile at a given geographic location the wind intensity is the lowest. In many locations this altitude is within the range of 22 to 26 kilometers.

In operation an SSP in a wireless telecommunication system according to the invention may be controlled to remain essentially geo-stationary or alternatively to move in the stratosphere in a desired fashion.

In a wireless telecommunication system according to the invention, each floating strato state platform may communicate with more than one ground station, and conversely each ground station may communicate with more than one floating platform. When the wireless telecommunication systems comprises a plurality of SSPs, two or more of them may, if desired, communicate with each other.

By yet another aspect of the invention there is provided a platform capable of floating in the stratosphere and of serving when airborne as a radio frequency energy transmitting station, which platform comprises an exoframe structure (as herein defined) having an inner space holding at least one inflatable balloon mounted within said inner space and capable of being filled with and retain a lighter-than-air gas; a communication package including signal acquisition means and radio frequency (RF) energy transmission means; electric power generator means; electric energy storage means; data acquisition means for providing altitude and spatial position data when the platform is airborne; navigation means responsive to said altitude and spatial position data to control the location and position of the platform, and computer means for energy management and navigation;

whereby the performance of the strato state platform is managed autonomously.

The said exoframe structure is preferably axisymmetric, e.g. ellipsoidal, spherical or a Goldsmith body and is a framework made of suitable structural elements such as rods, struts, beams, arches, rings or hoops and the like. Preferably, the exoframe structure is covered by an outer, pliable or rigid skin which serves both for protection and for minimizing the aerodynamic drag of the platform.

The said data acquisition means comprise typically a GPS unit and an inertial measurement unit which together acquire the required altitude and spatial position data.

If desired, the platform may also comprise sensor means for collecting data of environmental conditions such as temperature and pressure.

The energy management involves supplying during daytime electric energy to all electricity consuming systems and devices on the platform and diverting excess electric energy to said electric energy storage means; and during nighttime withdrawing from the said electric energy storage means the amounts of electric energy required for the operation of the platform and the communication system.

The electric energy storage means may, for example, be a storage battery, a regenerative fuel cell, or a lithium ion storage device.

The navigation means include a plurality of propulsion units each comprising an electric motor driven propeller and being preferably gimbaled to enable them to displace the platform horizontally, vertically and angularly as may be required. For assuming the right spatial position required at a given point of time in accordance with data fed into the computer by the said data acquisition means, each propulsion unit is associated with a servo motor.

The propellers are preferably of the low pressure type specially adapted for operation under stratospheric conditions, as known *per se*. During deployment the propulsion units under control of the navigation

system or of a ground station initially bring the platform according to the invention to the desired location whereupon the navigation system maintains the platform geo-stationary.

If desired, an SSP may be caused to cruise in the stratosphere as may be required.

As a rule there will be at least two electric motor/propeller propulsion units but if desired there may be more. The units may be fitted equatorially, e.g. on a main circumferential ring of the platform, or they may be fitted polarly, for example at the extreme ends of a structural shaft which transverses the platform from one pole to another.

In accordance with one embodiment of the invention the SSP comprises a large number of balloons, say 50 to 260, arranged in cluster form within the platform's body inner space. In this embodiment the body merely serves to hold the balloons and there is no interaction between them and the structure.

In accordance with another embodiment of the invention the SSP comprises one single balloon or a small number of balloons, say 4 to 8, and each balloon when fully inflated bears on the periphery of the body and on any neighboring balloon, whereby the single balloon or balloons between them fill essentially the entire inner space.

The outer skin preferably provided on the supporting structure may be mounted directly on peripheral structure members or alternatively on a set of dedicated booms.

Examples of materials of which the body and any booms may be made are aluminum, carbon fibers, Kevlar®, various epoxy resins and there are many others. The aerodynamic skin may for example be made of thin nylon sheets which need not be more than 6μ–12μ thick.

As mentioned a floating SSP according to the invention will be maintained at an altitude at which wind intensity is at its lowest, usually within the range of 22–26 kilometers, the exact altitude depending on the geographical location. At such altitudes the temperature is usually below −50°C and accordingly adequate thermal insulation is required for operative

parts such as batteries, electric and electronic components and the like and, where necessary, heating of critical components by means of suitable electric heating elements may also be provided. Additionally it is also possible to provide for the electric motors and other electric systems to idle during rest periods rather than to be switched off, in order to avoid damages or freezing during rest periods.

For the conversion of solar radiation into electric energy, fuel cells, light weight photovoltaic generators e.g. in the form of Si or Ga–As solar cell modules and the like may be used, all as known *per se*. Any such devices may be directly bonded or laminated to the platform's skin or applied to the exoframe structural elements and may, if desired, be fitted with means for the concentration of incident solar radiation.

The balloons of the platform may be of the zero pressure or super pressure type. Zero pressure means that at all times the pressure inside a balloon is equal to that of the surrounding atmosphere. In consequence, the balloons will increase volume during ascent. In order to ensure maintenance of zero pressure conditions it is necessary to release pressure during ascent, e.g. by using a stratified system of a light gas such as hydrogen or helium over air with the interposition of a pliable diaphragm. As the SSP ascends, air is bled off at a controlled rate which ensures zero pressure conditions at all time.

In a super pressure balloon the inner pressure inside a balloon is at all times higher than that of the surrounding atmosphere. In order to maintain a constant, usually small pressure difference between the inside and outside of the balloon, gas has to be bled off during ascent to ensure that the pressure difference does not exceed a desired predetermined value. To this end a stratified system of the kind specified above may again be used and the bleeding off of the air will be so controlled that the desired pressure increment is maintained.

A super pressure regime at the target altitude may also be achieved by so designing the supporting structure that each balloon bears on structural members of the SSP and on any neighboring balloon whereby

expansion during ascent is restrained. In such an arrangement an initially zero pressure balloon turns during ascent into a super pressure one. It is possible in such an arrangement to have a gas–over–air stratification and to so choose the gas quantity that only at the target altitude all air is expelled and the gas reaches the desired super pressure.

It is to be noted that a stratified gas–over–air arrangement in balloons is known *per se* and does as such not form part of the present invention.

It has been found that balloons with a super pressure regime at least at the target altitude of the SSP are superior to zero–pressure balloons in maintaining the desired altitude, which may reduce the operational load on the navigation system.

Because of its size an SSP according to the invention is preferably assembled at the launching site which has to be protected from strong winds. After assembly the balloons are inflated with lighter–than–air gas, typically hydrogen or helium, while the platform is suitably restrained. The quantity of the inflating gas is so chosen that buoyancy will be achieved at the design altitude, say 24 km. Upon completion of the gas filling operation the SSP is lifted uniformly with the aid of auxiliary balloons which are later discarded.

BRIEF DESCRIPTION OF THE DRAWINGS

For better understanding the invention will now be described with reference to the annexed drawings in which:

Fig. 1 shows schematically an embodiment of a super pressure balloon for use as a cluster constituent in a platform according to the invention;

Fig. 2 is a schematic elevation of one embodiment of a platform according to the invention;

Fig. 3 is an equatorial cross section of the platform taken along line III–III of Fig. 2;

Fig. 4 is a schematic elevation of another embodiment of a platform according to the invention;

Figs. 5 and 6 are respectively a schematic elevation and plan view of yet another embodiment of a platform according to the invention;

Fig. 7 is a schematic vertical section across yet another embodiment of a platform according to the invention;

Fig. 8 shows schematically the launching procedure of a platform according to the invention;

Fig. 9 shows schematically the landing procedure of a platform according to the invention;

Fig. 10 is a schematic cut-away perspective view of a further embodiment of a platform according to the invention;

Figs. 11 and 12 are, respectively, elevation and plan view of the embodiment of Fig. 10;

Fig. 13 is a section across two balloons used in the embodiment of Figs. 10 to 12, taken along line XIII-XIII in Fig. 14;

Fig. 14 is a section along lines XIV-XIV in Fig. 13;

Fig. 15 is a graphical representation of the wind velocity vs. altitude in Israel;

Fig. 16 is a similar graphical representation for a location in the U.S.A.;

Fig. 17 is a graphical representation showing an example of the energy balance in a spherical platform according to the invention;

Fig. 18 shows the radio horizon R plotted against altitude; and

Fig. 19 is a block diagram of the avionics in a platform according to the invention.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

Turning first to Fig. 1 there is shown a typical super pressure balloon **1** suitable for use in a platform according to the invention. As shown the balloon has a body **2** fitted with a pair of diametrically opposed tie fittings **3** interconnected by an internal tension element **4**, e.g. a rope. In the embodiment here shown only one pair of tie fittings with associated

tension element is shown but if desired the balloon may comprise several tie fittings/tension element assemblies always providing that the two pair forming tie fittings are diametrically opposed. As shown, each of the tie fittings **3** comprises a pad **5**. One of the tie fittings **3** comprises a filling or inflating valve **6** and the other one a vent valve **7**. If desired, a single valve aggregate may be used for both filling and venting.

On the outside each of the two tie fittings **3** comprise a loop **8** for connection of the balloon to other balloons or to a member of the supporting structure.

Turning now to Figs. 2 and 3 there is shown schematically one embodiment of a platform according to the invention with a cluster of balloons arranged in a single layer. As shown, the platform **9** is a flat, essentially hollow ellipsoid with a circular cross-sectional shape and comprises a variety of structural elements such as a peripheral ring **10**, a plurality of radial beams **11** and vertical struts **12** and there may be provided reinforcing braces, ties and ropes which are not shown. The entire structure is covered by a thin nylon skin (not shown) which at selected regions is laminated with a plurality of lightweight photovoltaic electricity generators such as Si or Ga–As solar cell modules (not shown) comprising an ultra–light silicon or gallium – arsenide foil, as known *per se*.

Inside the structure there is mounted a single layered balloon cluster comprising a plurality of balloons **14**, e.g. of the kind shown in Fig. 1, which between them provide the required lift for bringing the platform to the desired altitude and the necessary buoyancy for keeping it there.

At its two poles the platform comprises two or more propulsion units **15** each having a gimbaled electrical motor driving a low pressure propeller. Each propulsion unit **15** is associated with a servo motor (not shown) for adjustment of the spatial orientation.

In its interior the platform is fitted with avionics **16** and a payload package **17**.

The platform according to the invention schematically illustrated in Fig. 4 is of spherical shape. As shown, the platform **21** is an essentially hollow body that comprises vertical rings **22** only one of which is shown, and horizontal rings **23**, **24** and **25** vertically spaced from each other, and there is also provided an outer skin supported by all rings **22** and **23** to **25**, also not shown. In addition, the structure comprises a plurality of beams, struts, braces, tensioning ropes etc. designed in a manner which will impart the required strength and stability, as known to persons skilled in the art.

Within the areas enclosed by horizontal rings **23–25** there are located a plurality of balloons of different sizes such as balloons **26**, **27** and **28**.

Similar as in the embodiment of Figs. 2 and 3, the platform has two or more gimbaled propulsion units comprising each an electric motor driven propeller with an associated servo motor, avionics and a payload package, all of which are not shown in Fig. 4.

The embodiment of the platform according to the invention shown in Figs. 5 and 6 is essentially similar to that of Figs. 2 and 3 but the balloons here are arranged in two superimposed layers. As shown, the platform **30** comprises a central tubular shaft **31** which supports structural rings **32** and a plurality of radial beams **33** to **36**.

Two layers of balloons **37** are associated with each of rings **32** and as these balloons emerge beyond the radial beams **33** to **36**, dedicated booms are required for supporting an outer skin. For simplicity of illustration both the booms and skin are not shown.

Inside shaft **31** there are mounted two gimbaled propulsion units **38** comprising each an electrical motor driven propeller associated with a servo motor and, similar as in the embodiment of Figs. 2 and 3, the platform of this embodiment also includes avionics and a payload package both of which are not shown.

The balloon cluster comprises a plurality of balloons of different sizes such as **39**, **40** and **41**.

In the embodiment of Fig. 7 the platform **43** comprises a central tubular shaft **44**, two structural rings **45** interconnected by struts **46** which in turn comprise reinforcing braces **47**. There are further provided beams such as **49** and **50**. The balloon cluster comprises a plurality of balloons **51** arranged essentially in two layers and vertical rows, and the structure is covered by an outer skin and carries propulsion units, avionics and a payload package, all of which are not shown.

Attention is now directed to Fig. 8 which is a schematic illustration of the launching procedure of an SSP according to the invention from a ground installation. As shown, a platform according to the invention **50** fitted with auxiliary balloons **51** and which is assumed to have been assembled *in situ*, is suspended within a launching pit **52** forming part of the ground installation. The platform **50** is retained in pit **52** by a plurality of cables **53** and **54** anchored in, respectively, anchor pillars **55** and **56**.

The ground installation further comprises a rigging system with cables and winches as shown, which is fitted with auxiliary balloons **57** and **58**. Furthermore, the ground installation comprises a ground station **59** for the transmission of launching commands to the platform **50**.

Upon a first command from transmitter **59**, cables **53** and **54** are disconnected whereupon the lighter–than–air platform **50** is lifted uniformly from position A to position B. When in position B a second command disconnects the rigging system whereupon the platform is lifted uniformly to position C. At that position a third command disconnects the auxiliary balloons **51** whereupon the platform **50** rises to position D and from there, by the driving force of its own lift and with the aid of its own suitably programmed navigational system, or alternatively by control from the ground station **59**, reaches the desired location in the stratosphere.

The landing procedure of a platform according to the invention is shown schematically in Fig. 9. The landing procedure is initiated by a command which may originate from the platform itself, e.g. in consequence of preprogramming or in response to some failure, or alternatively may

originate from ground station **59**. In consequence, gas begins to bleed off from some of the balloons so chosen as to keep a stable trim. At a certain altitude, say about 750 meters, an anchor chord **60** is released from the platform **50** and is manually connected to a winch borne by a tractor **61**. The platform is now pulled so as to be properly positioned above pit **52**. Further anchor chords **60** (not shown) are then released and connected to stationary winches and the platform is now cranked down against its lift and at the end of the operation is connected to anchor pillars such as pillar **62**.

The embodiment of a platform according to the invention shown in Figs. 10 to 12 is designed to accommodate four large size balloons **73** which are designed to reach a super pressure state upon arrival at the target altitude of say 24 km and to behave until then as zero pressure balloons. As shown, in this embodiment of the invention the platform **65** is an essentially hollow body being a framework made of a plurality of peripheral arches **66**, a plurality of circumferential rings such as rings **67** and a network of peripheral braces and stays which are clearly visible in Figs. 10 to 12 and are not separately numbered.

The platform further comprises a central shaft **68** bearing at its two extreme ends upper and lower compartments **69** which hold the avionics, electric motors, batteries and all other operational components. On top, each compartment **69** bears a suitably gimbaled propeller **70** whose spatial orientation is controlled by a servo motor located inside the associated compartment **69** and which is driven by an electric motor equally located inside the compartment.

The structure is covered by an outer skin **71** which carries at the structure's top region a plurality of photovoltaic generators **72**.

The design of the balloons is more closely illustrated in Figs. 13 and 14. As shown, each balloon **73** has an internal diaphragm **74** which divides the balloon into an upper compartment **75** and a lower compartment **76**, which latter is fitted with a vent **77**. For launching, compartment **75** is filled with a lighter-than-air gas, such as hydrogen or helium, while

compartment 76 is full of air. As the balloon ascends, the gas inside compartment 75 tends to expand and inflate the balloon as a result of the pressure difference between the inside of compartment 75 and the surrounding atmosphere. As, however, the expansion of the balloon is restrained by the peripheral structure of the platform and by the two neighboring balloons 73, the expanding gas inside compartment 75 depresses diaphragm 74 whereby air is expelled via vent 77. Thus, as the ascent progresses, and since the inflation of the balloon is restrained, more air is expelled from compartment 76 and the quantity of the gas inside compartment 75 is so calculated that zero pressure conditions are maintained throughout the ascent, meaning that the pressure inside the compartment 75 is at all times equal to the outside pressure. Shortly before the platform reaches the target altitude of say 24 km, the diaphragm 74 has been depressed to its utmost and the pressure inside compartment 75 now rises slightly whereby the super pressure conditions are established at the design altitude.

Attention is now directed to Fig. 15 which shows typical wind velocities vs. altitude in Israel. In Fig. 15 the solid line shows the average wind as actually measured and the dotted line shows the 3–sigma probability velocities.

Turning now to Fig. 16 there are shown the wind velocities vs. altitude for a location in the U.S.A. The three curves show the probable velocities at 50%, 20% and 1% probability and there are additional fractional curves which show the 5% and 10% probabilities.

As can be seen from both Figs. 15 and 16 at the two given geographic locations the wind velocity is minimal at 24 kilometers and therefore at those locations this is the preferred altitude for the deployment of a platform according to the invention.

Fig. 17 shows the energy balance for a spherical platform according to the invention having the characteristics given in the following Tables 1 and 2, which characteristics are by way of example only.

TABLE 1

Balloons						
Parameter	Units					
SSP Diameter	meter					136
Balloon Qty		137	12	36	72	257
Balloon diameter	meter	15	13	8	5	
Balloons Surface	m^2	96,839	6371	7238	5655	116,103
Skin thickness	μm	12	12	12	12	
Skin weight	kg	1,452	96	110	85	1,743
Balloons volume	m^3	242,100	13,800	9,651	4,712	270,263
Gross lift at 24 km	N	113,635	6,480	4,530	2,220	126,865

TABLE 2

Propulsion System							
Element			Units				
Propeller efficiency			%	75	75	80	80
Solar collector area			m^2	1,300	1,300	1,200	1,200
Solar collector weight			kg	424	424	400	400
Battery weight			kg	2,096	2,133	1,885	1,992
Propulsion system weight			kg	276	276	271	271
System total power requirements	electric motors	day	Watt	32,424	32,424	30,397	30,397
		night	Watt	11,523	11,523	10,803	10,803
	Control auxiliary system		Watt	600	600	600	600
Payload			kg	309	271	557	520
Available power for payload		Day	Watt	1,000	1,200	1,000	1,200
		night	Watt	1,000	1,200	1,000	1,200

In Fig. 17 -x- shows the system's total power requirement; -+- shows the available solar energy; and -□- shows the power balance which is positive when the battery is being charged and negative at night time when electric power is consumed without any recharging.

Fig. 18 in which the radio horizon R is plotted against altitude, shows that the radio horizon curve gradually flattens with a range of 22–26 kilometers.

An example of the avionics in a platform according to the invention is shown in the block diagram of Fig. 19.

Generally speaking the avionics include a GPS unit and an inertial measurement unit continuously managing via telemetric control unit TLM.C the angular velocity and linear acceleration of the platform by means of altitude and spatial position data which they continuously generate, whereby the platform is stabilized in its predetermined position or moves in a predetermined pattern, as the case may be. The avionics further include a power management unit PMU which controls the electric power supply to all power consuming components of the platform and payload, and the storage and withdrawal of electric energy in and from the electric storage batteries.

There is further provided a main electronics unit MAIN.U which includes among others a central processor unit CPU for the management of the operation of the platform and the mission of the payload.

The avionics further include a sensor unit which collects environmental data such as temperature and pressure, and performs the A/D conversion. The MAIN.U further comprises an input/output control unit IO.C, a power supply control unit PS.C, and UP/DNL unit for the control of an uplink/downlink communication channel, and an internal transcriber TRANS linked to antenna front end unit AFE which latter includes an external antenna. Data furnished by the sensors are transmitted downlink via the UP/DNL unit.

The power management unit PMU performs the following tasks:

i) controls and regulates the voltage generated by the photo-voltaic generators and distributes electric power to the various power consuming components of the system as required;

ii) controls the loading of the batteries during daytime and the withdrawal of electrical power from the batteries at night;

iii) controls the operational regime during daytime and at night according to priorities;

iv) disconnects low priority electricity consuming components when electric power supply from the battery becomes scarce;

v) prevents total discharge of the batteries and the occurrences of inrush currents; and

vi) switches on a standby emergency battery in case of failure of the main batteries.

The electrical controller units are part of the platform's control system with the task of controlling the rotational speed of the electric propeller motors.

The electrical actuation driver units EAD.U have the task of controlling the pitch and angular positions of the propulsion units. The control commands to the propulsion/navigation system are transmitted from the CPU via the IO.C unit to the EADs and/or the electric controllers and from there to the main electric motors and servo motors. Thus in the system here shown which has two propulsion units, the avionics provide the following three controls: (i) control of the rotational speed of the propeller; (ii) control of the propeller pitch; (iii) control of the angular position of the propulsion units.

In the embodiment here shown the platform comprises four GPS antennas and one receiving/transmitting antenna for external UP/DNL communication.

The system here shown further comprises a set of main batteries and an emergency battery. During daytime electric power for consumption is supplied directly from the photovoltaic cells and may, if necessary, be supplemented by power supply from the batteries. At night time the entire electric power supply is from the batteries. The loading and withdrawal of electric power to and from the batteries is managed by the PMU under control of the CPU. The emergency battery serves only for high priority emergency such as, for example initiating the platform's descent in case of power failure.

The following is an example of a specification for the construction of a platform according to the invention:

Balloons

Type:	Super Pressure Balloon as developed by Winzen International Inc.
Skin material:	Orthotropically pre-stressed Nylon 6.
Skin thickness:	6 to 25 microns
Skin weight ω:	ω=7.5 to 31.5 gr/m^2

Solar Energy Cells: Such as developed by Siemens Solar, Inc.

Propeller Efficiency:	70% (minimum)
Electric Motor Efficiency:	90% (minimum)
Power storage overall efficiency:	>90% (typical)
Accumulators capacity requirement:	60 to 90 Watt.hour/kg
Propulsion system weight:	200 kg

CLAIMS:

1. A method of wireless telecommunication comprising floating in the stratosphere at a desired altitude an essentially exoframe structure having an inner space holding at least one inflatable balloon mounted within said inner space and capable of being filled with and retain a lighter-than-air gas, a communication package including signal acquisition means and radio frequency (RF) energy transmission means, electric power generator means, electric energy storage means, data acquisition means for providing altitude and spatial position data when the platform is airborne, navigation means responsive to said altitude and spatial data to control the location and position of the platform, and computer means for energy management and navigation; at least one lighter-than-air strato state platform which platform comprises establishing at least one ground station capable of communicating with said lighter-than-air platform; and establishing a communication channel between at least one platform and a ground station.

2. The method of Claim 1, wherein said electric power generator means comprise means for converting solar radiation into electric energy.

3. The method of Claims 1 or 2, wherein the platform is designed to maintain autonomously a geo-stationary position throughout operation.

4. The method of any one of Claims 1 to 3, wherein said signal acquisition means are designed to receive communication signals.

5. The method of any one of Claims 1 to 3, wherein the signals are processed from information acquired autonomously by the strato state platform.

6. The method of Claim 5, wherein said information is images acquired by means being a member selected from the group consisting of cameras and radar devices.

7. The method of any one of Claims 1 to 6, wherein said strato state platform is floating at an altitude within the range of about 22 to 26 kilometers.

8. A wireless telecommunication system that includes at least one lighter–than–air, strato state platform floating at a suitable altitude, which platform comprises an exoframe structure having an inner space holding at least one inflatable balloon mounted within said inner space and capable of being filled with and retain a lighter–than–air gas, a communication package including signal acquisition means and radio frequency (RF) energy transmission means, electric power generator means, electric energy storage means, data acquisition means for providing altitude and spatial position data when the platform is airborne, navigation means responsive to said altitude and spatial position data to control the location and position of the platform and computer means for energy management and navigation; a ground station; and a communication channel between said lighter–than–air platform and ground station.

9. The wireless telecommunication system of Claim 8, wherein said electric power generator means comprise at least one fuel powered electricity generator.

10. The wireless telecommunication system of Claim 8, wherein said electric power generator means comprise means for converting solar radiation into electric energy.

11. The wireless telecommunication system of any one of Claims 8 to 10, wherein each floating strato state platform communicates with more than one ground station.

12. The wireless telecommunication system of any one of Claims 8 to 10, wherein each ground station communicates with more than one strato state platform.

13. The wireless communication system of any one of Claims 8 to 10, comprising a plurality strato state platforms, wherein at least two platforms communicate with each other.

14. A platform capable of floating in the stratosphere and of serving when airborne as a radio frequency energy transmitting station, comprising an exoframe structure having an inner space holding at least one inflatable balloon mounted within said inner space and capable of being filled with

and retain a lighter–than–air gas; a communication package including signal acquisition means and radio frequency (RF) energy transmission means; electric power generator means; electric energy storage means; data acquisition means for providing altitude and spatial position data when the platform is airborne; navigation means responsive to said altitude and spatial position data to control the location and position of the platform; and computer means for energy management and navigation; whereby the performance of the strato state geo–stationary platform is managed autonomously.

15. The platform of Claim 14, wherein said electric power generator means comprise at least one fuel powered electricity generator.

16. The platform of Claim 13, wherein said electric power generator means comprise means for converting solar radiation into electric energy.

17. The platform of any one of Claims 14 to 16, wherein said data acquisition means comprise a GPS unit and an inertial measurement unit.

18. The platform of any one of Claims 14 to 16, wherein the energy management means are capable of supplying during daytime electric energy to all electricity consuming systems and devices on the platform and diverting excess electric energy to said electric energy storage means; and during nighttime withdrawing from the said electric energy storage means the amounts of electric energy required for the operation of the platform and the communication system.

19. The platform of any one of Claims 14 to 18, wherein said electric energy storage means is at least one electric storage battery.

20. The platform of any one of Claims 14 to 18, wherein said electric energy storage means is a regenerative fuel cell.

21. The platform of any one of Claims 14 to 18, wherein said electric energy storage means is a lithium ion storage device.

22. The platform of any one of Claims 14 to 21, wherein said navigation means are at least two propulsion units comprising each an electric motor driven propeller.

23. The platform of Claim 22, wherein said propulsion units are gimbaled and are each associated with a servo motor.

24. The platform of any one of Claims 14 to 23, being a spherical body.

25. The platform of any one of Claims 14 to 23, being an ellipsoidal body.

26. The platform of any one of Claims 14 to 23, being a Goldsmith body.

27. The platform of any one of Claims 23 to 26, wherein the said propulsion units are mounted at the two poles of the platform.

28. The platform of any one of Claims 23 to 26, wherein the said propulsion units are mounted at the equatorial region of the platform.

29. The platform of any one of Claims 23 to 28, wherein said propulsion unit comprise at least one low pressure type propeller.

30. The platform of any one of Claims 14 to 29, comprising a cluster of balloons.

31. The platform of any one of Claims 14 to 29, comprising a single balloon which upon inflation fills the entire inner space of the body whereby it is restrained from further inflation.

32. The platform of any one of Claims 14 to 29, comprising a small number of balloons and each balloon upon inflation bears on the periphery of the body and on neighboring balloons, whereby it is restrained from further inflation.

33. The platform of Claim 32 comprising from 4 to 8 balloons.

34. The platform of any one of Claims 14 to 33, comprising an outer skin.

35. The platform of Claim 34, wherein said outer skin is mounted on peripheral structural members of the body.

36. The platform of Claim 34, wherein said outer skin is mounted on dedicated booms.

37. The platform of any one of Claims 14 to 36, wherein said electric power generator means are light weight photovoltaic cells.

38. The platform of Claim 37, wherein said photovoltaic cells are mounted on said outer skin.

39. The platform of any one of Claims 14 to 38, wherein the balloons are of the zero pressure type.

40. The platform of any one of Claims 14 to 38, wherein the balloons are of the super pressure type, means being provided for maintaining during ascent a desired pressure difference between the interior of each balloon and the surrounding atmosphere.

41. The platform of any one of Claims 14 to 38 comprising means by which each balloon performs by a zero pressure regime during ascent and shifts to super pressure at the target altitude.

42. The platform of any one of Claims 14 to 41, comprising sensor means for collecting data of environmental conditions.

43. The platform of Claim 42, wherein said environmental conditions are temperature and pressure.

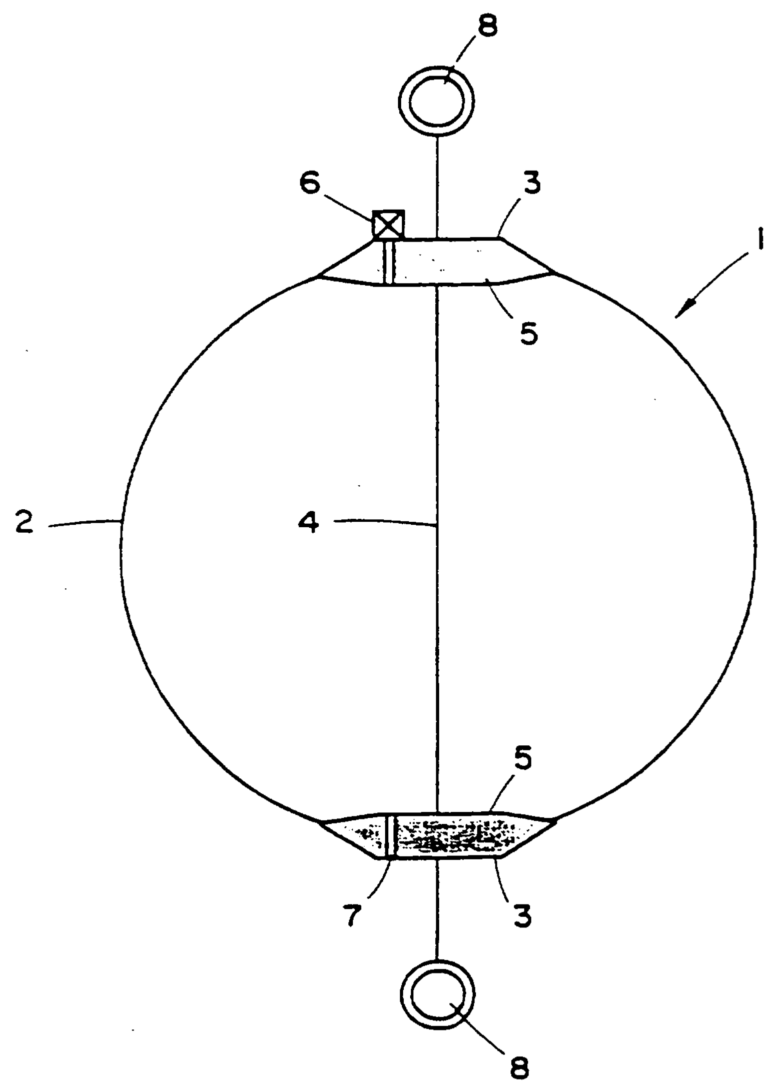
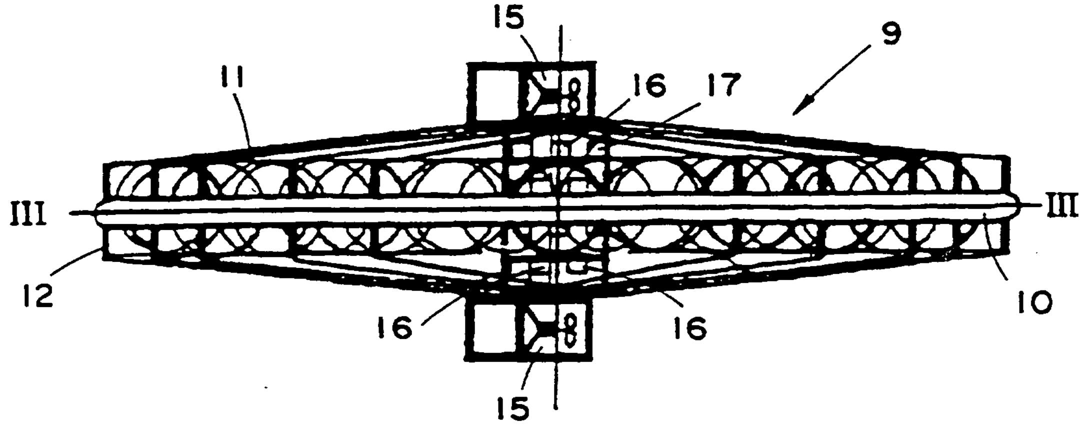


Fig. 1

Fig.2



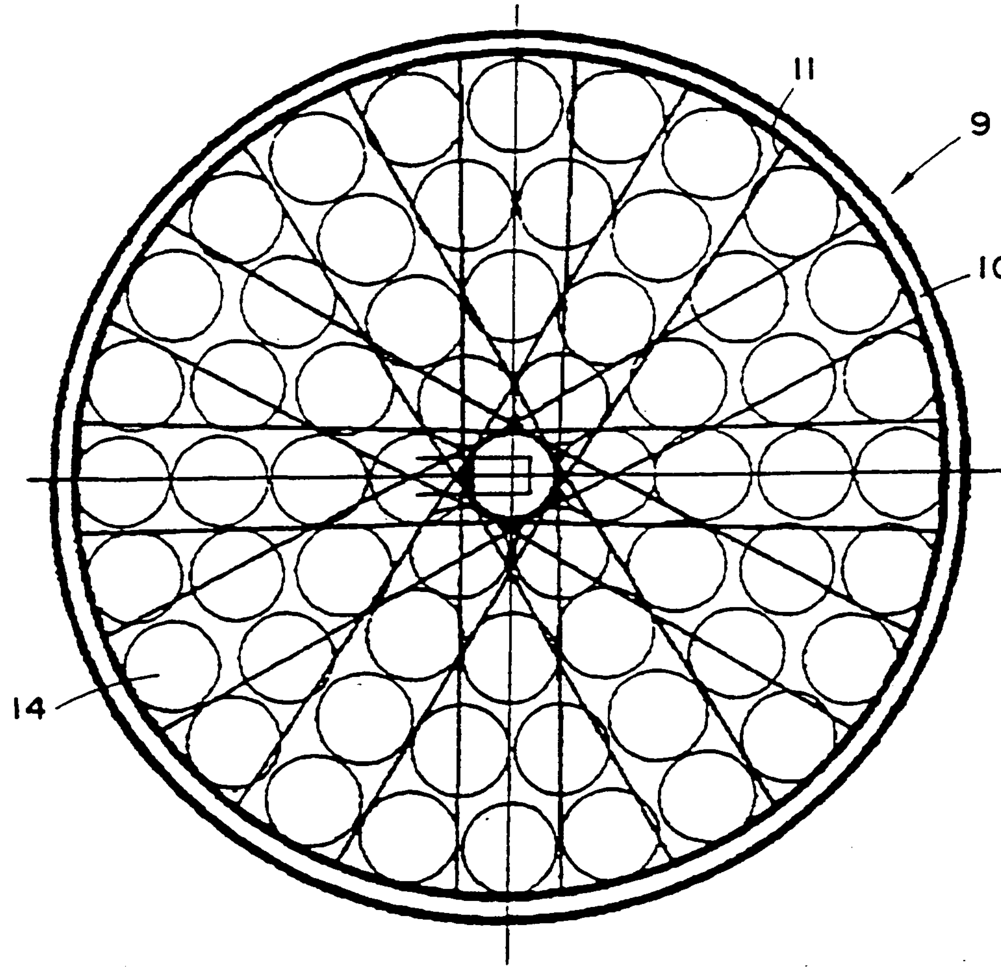


Fig.3

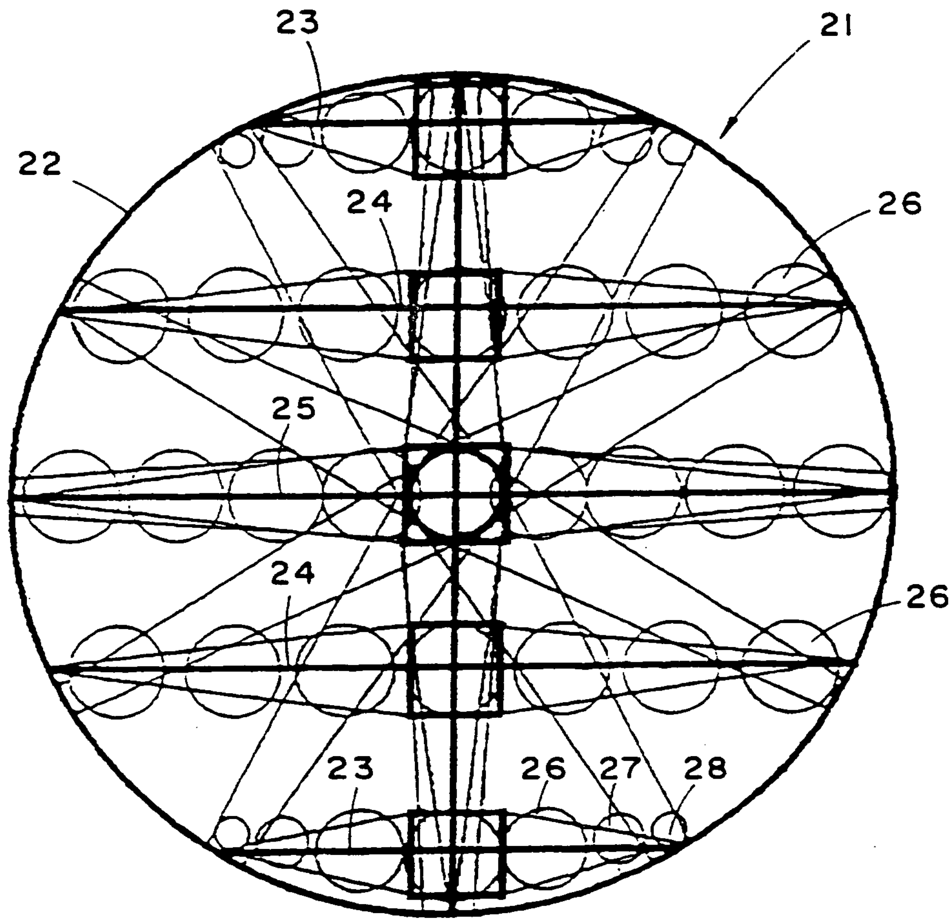
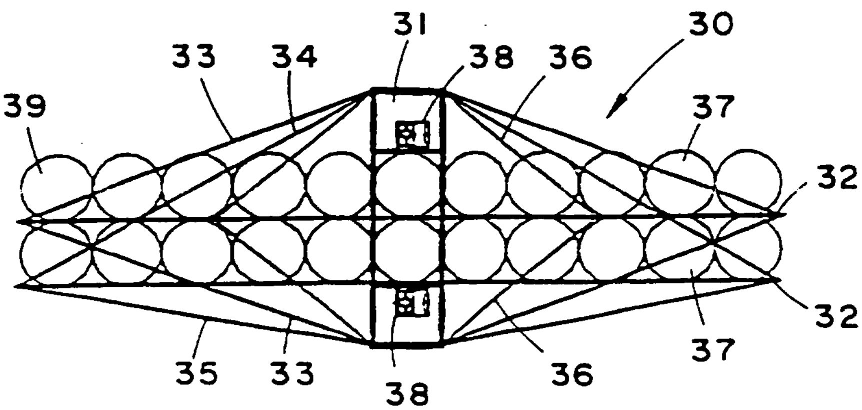


Fig.4

Fig.5



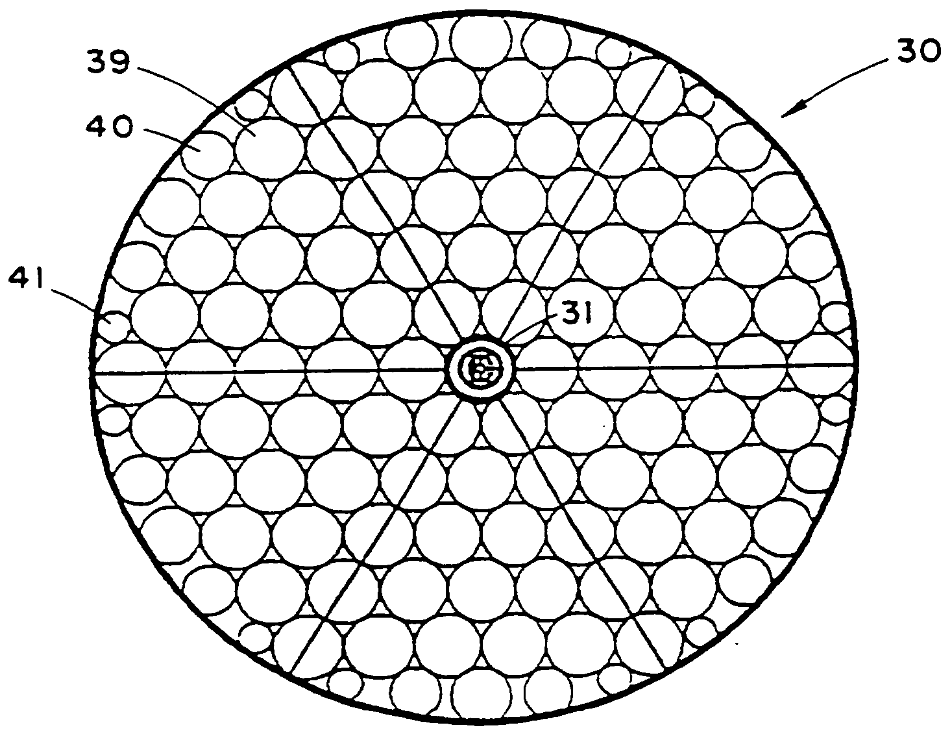


Fig.6

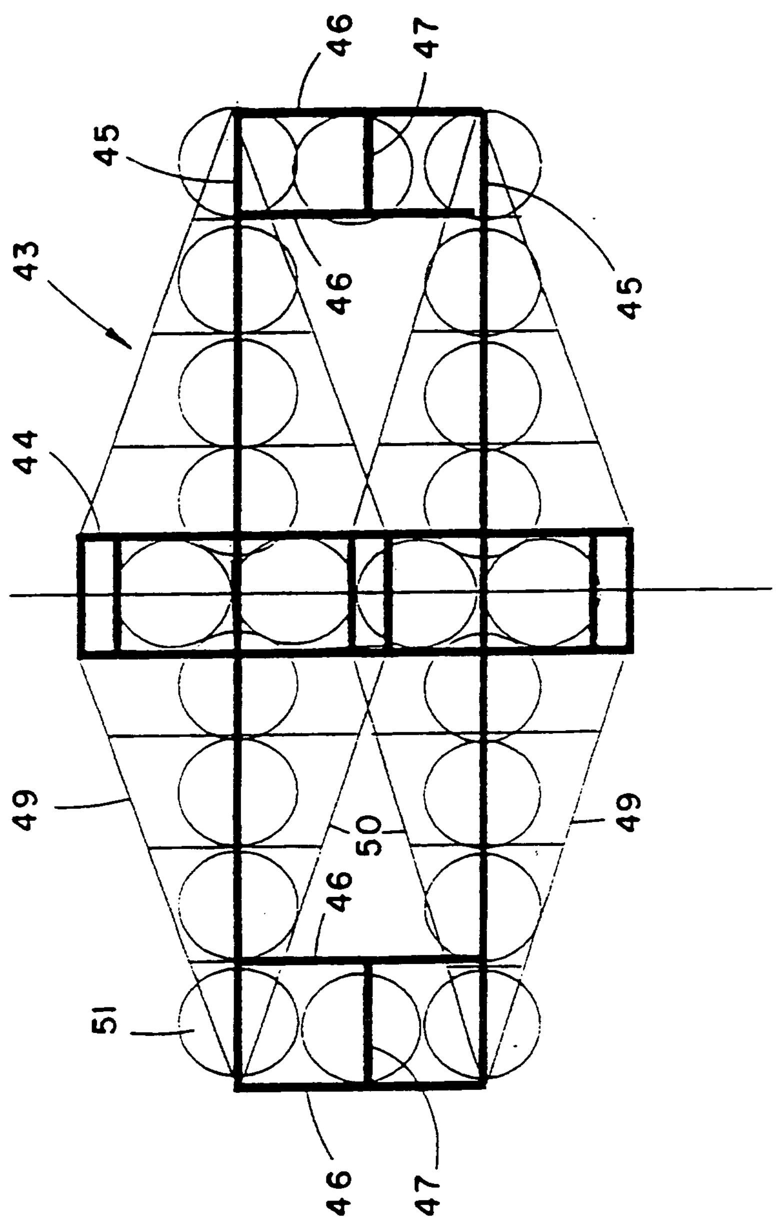


Fig. 7

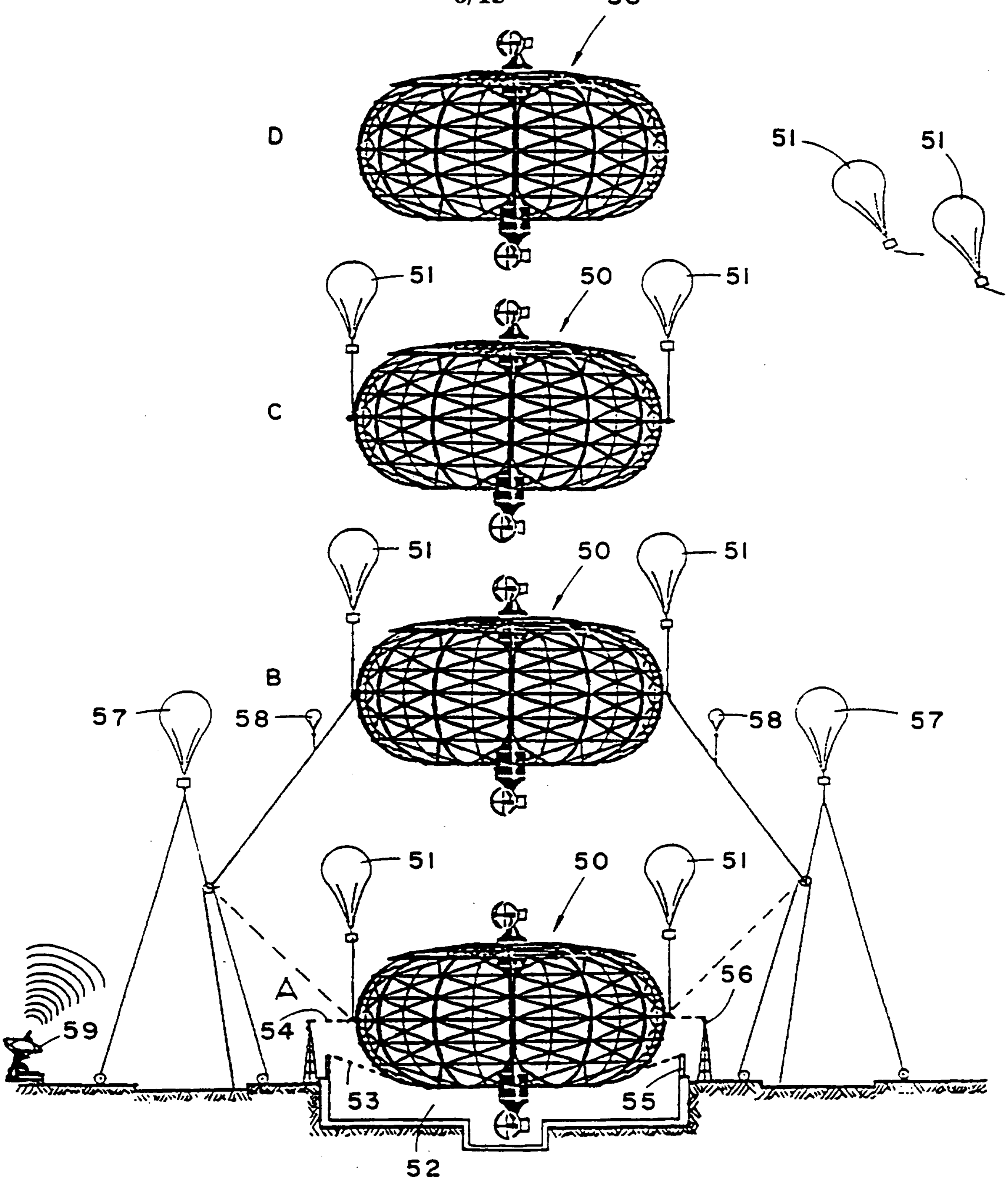


Fig. 8

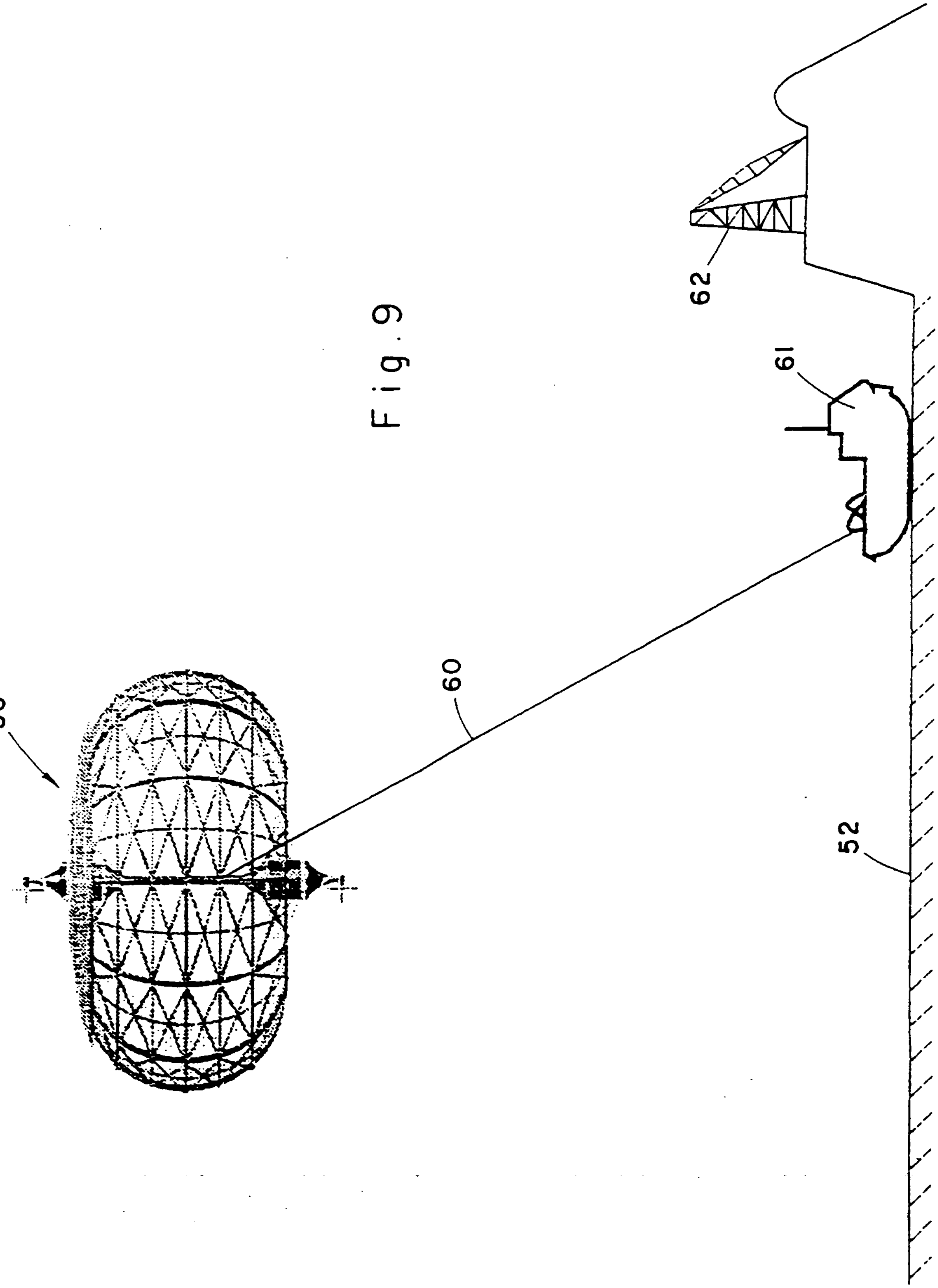


Fig.9

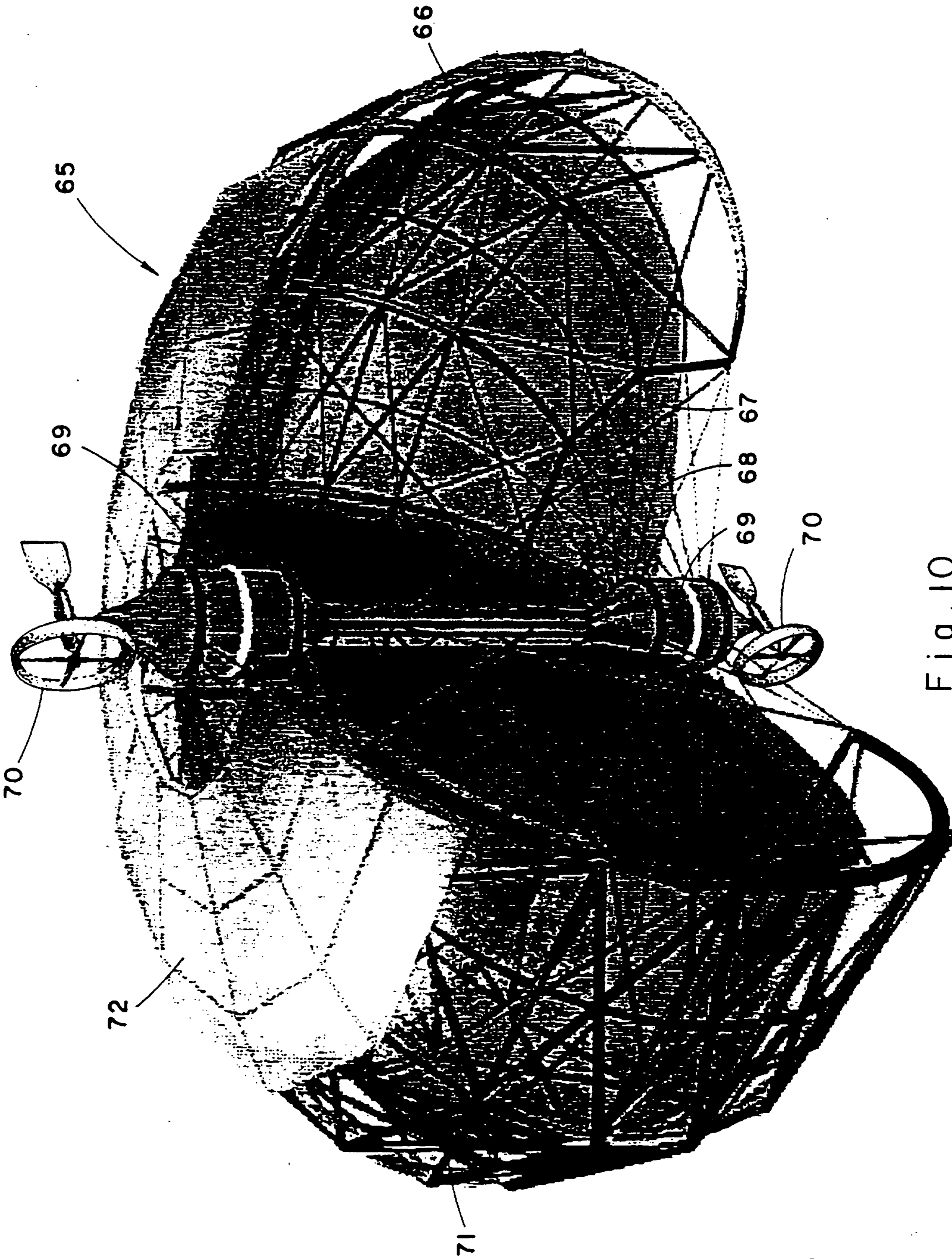


Fig. 10

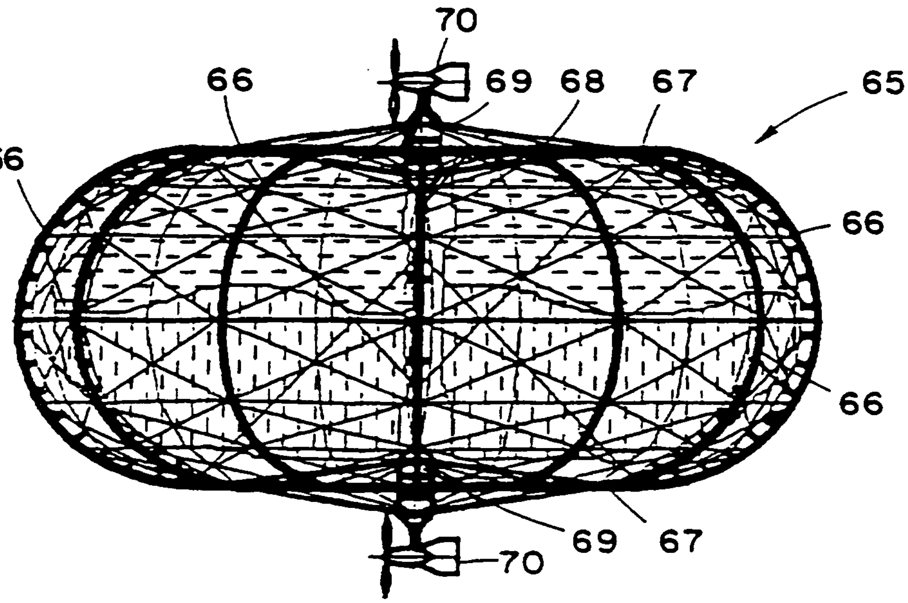


Fig.11

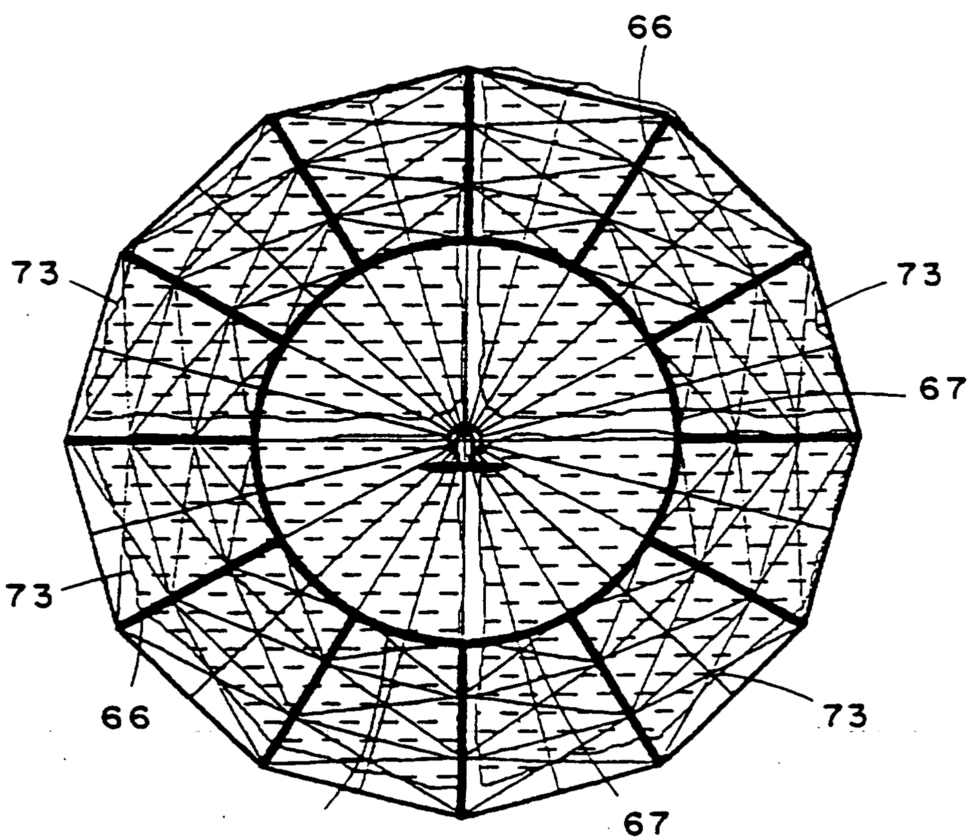


Fig.12

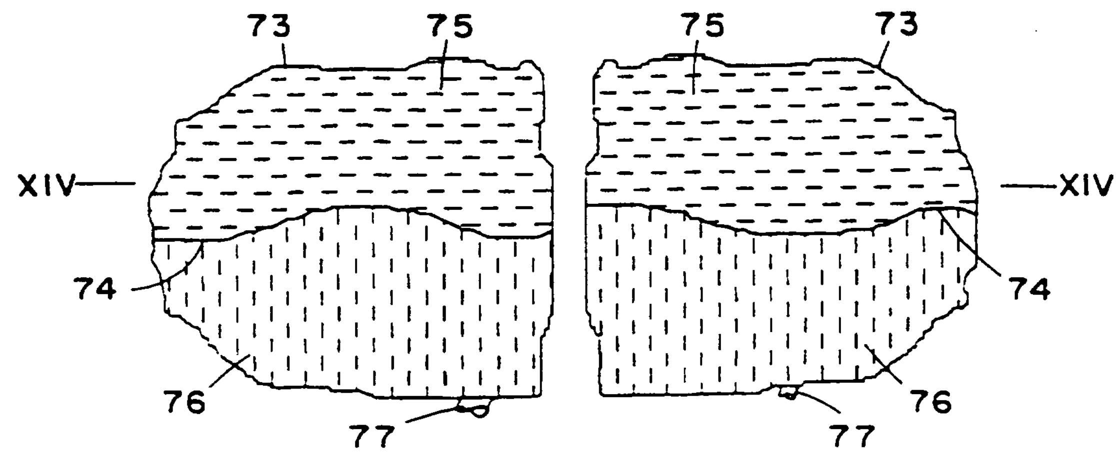


Fig. 13

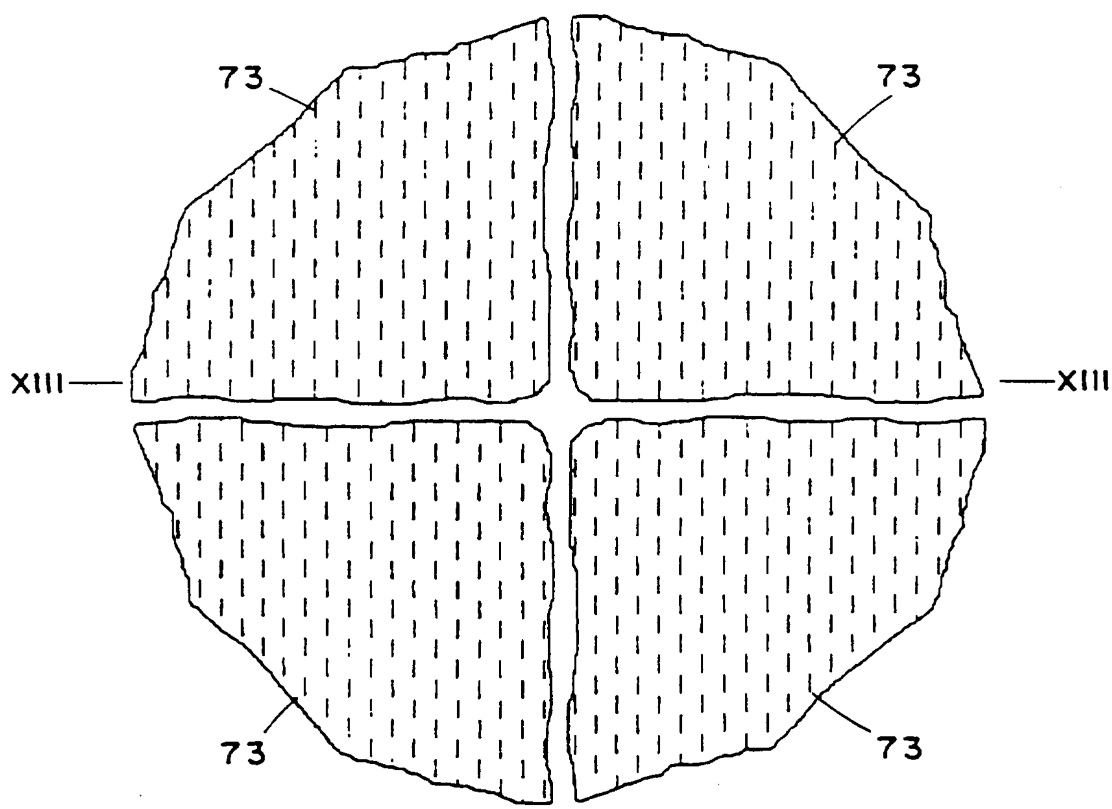


Fig. 14

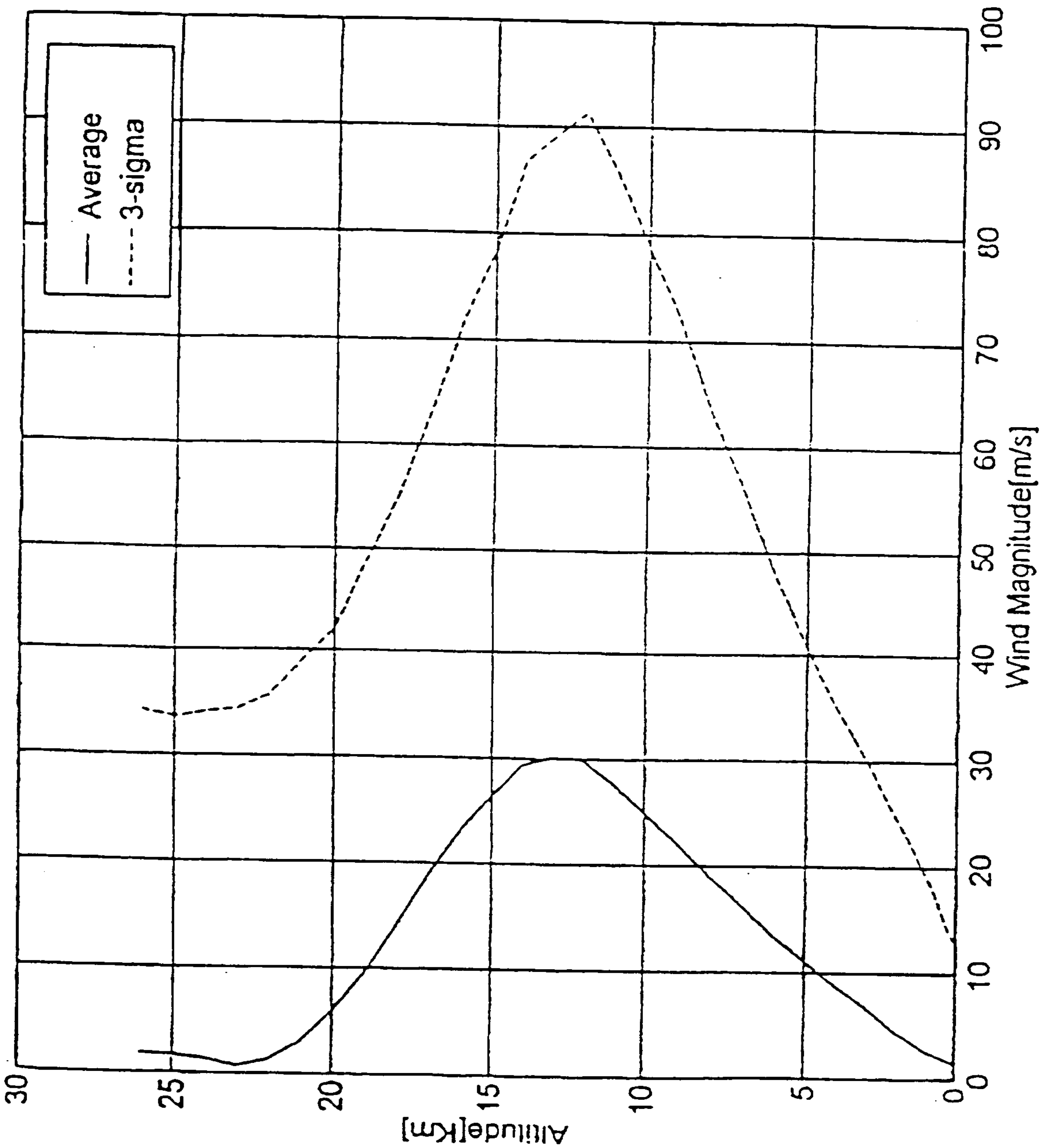
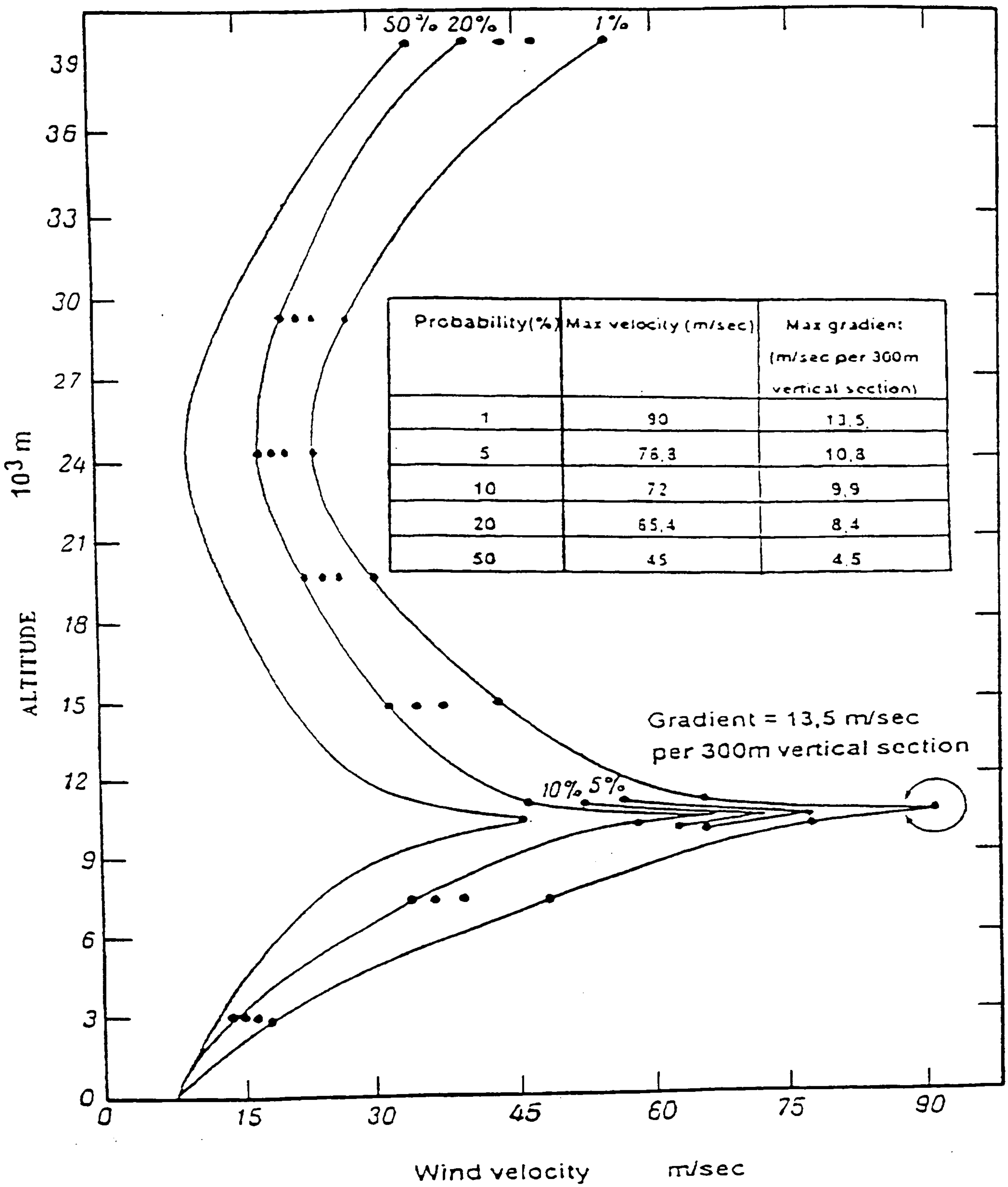

Average
3-sigma
Altitude[Km]
Wind Magnitude[m/s]
0
5
10
15
20
25
30
0
10
20
30
40
50
60
70
80
90
100

Fig. 15



Probability(%)	Max velocity (m/sec)	Max gradient (m/sec per 300m vertical section)
1	90	13.5
5	76.3	10.8
10	72	9.9
20	65.4	8.4
50	45	4.5

Fig.16

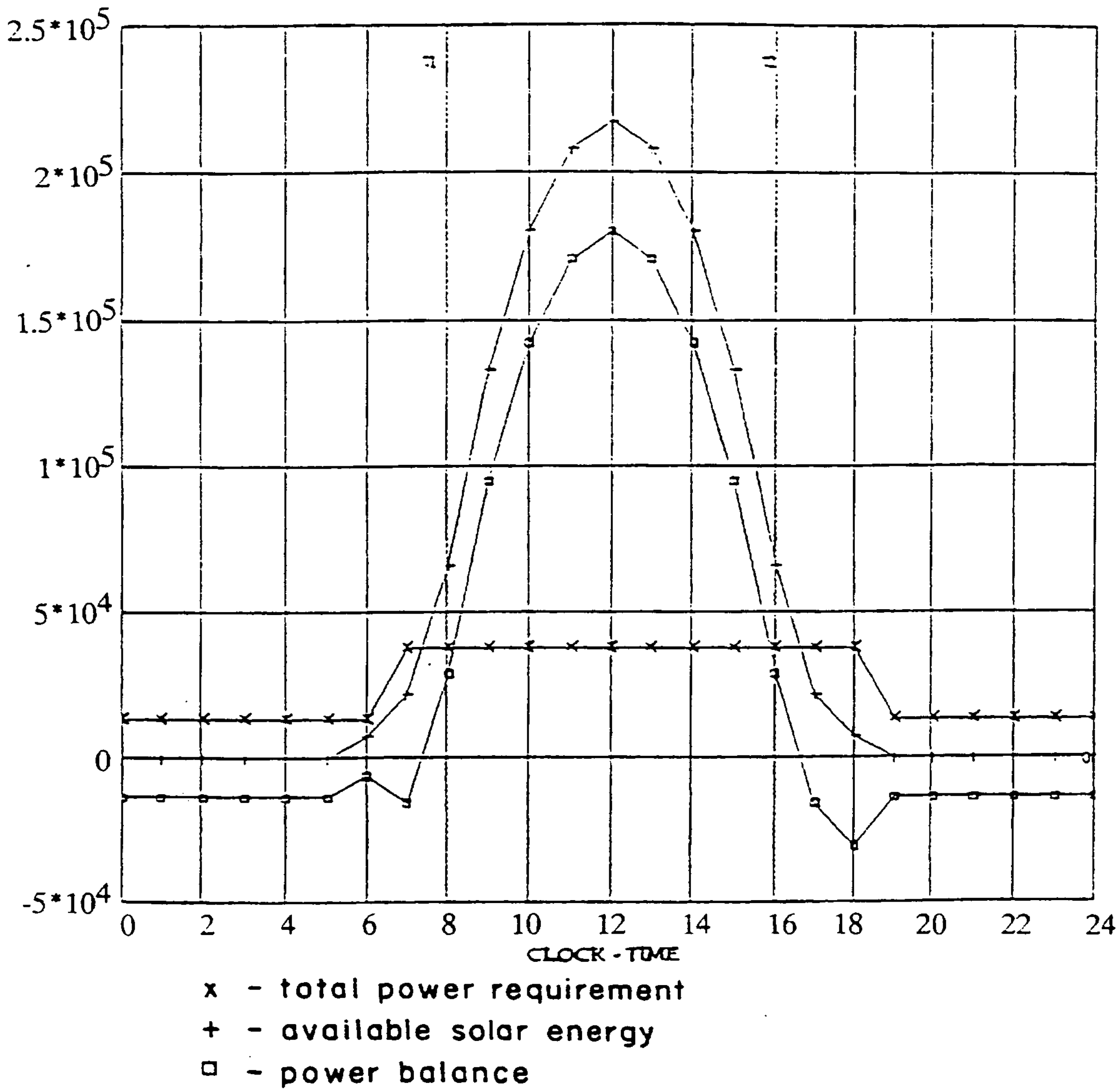

2.5*10^5
2*10^5
1.5*10^5
1*10^5
5*10^4
0
-5*10^4
0 2 4 6 8 10 12 14 16 18 20 22 24
CLOCK - TIME
x - total power requirement
+ - available solar energy
□ - power balance

Fig.17

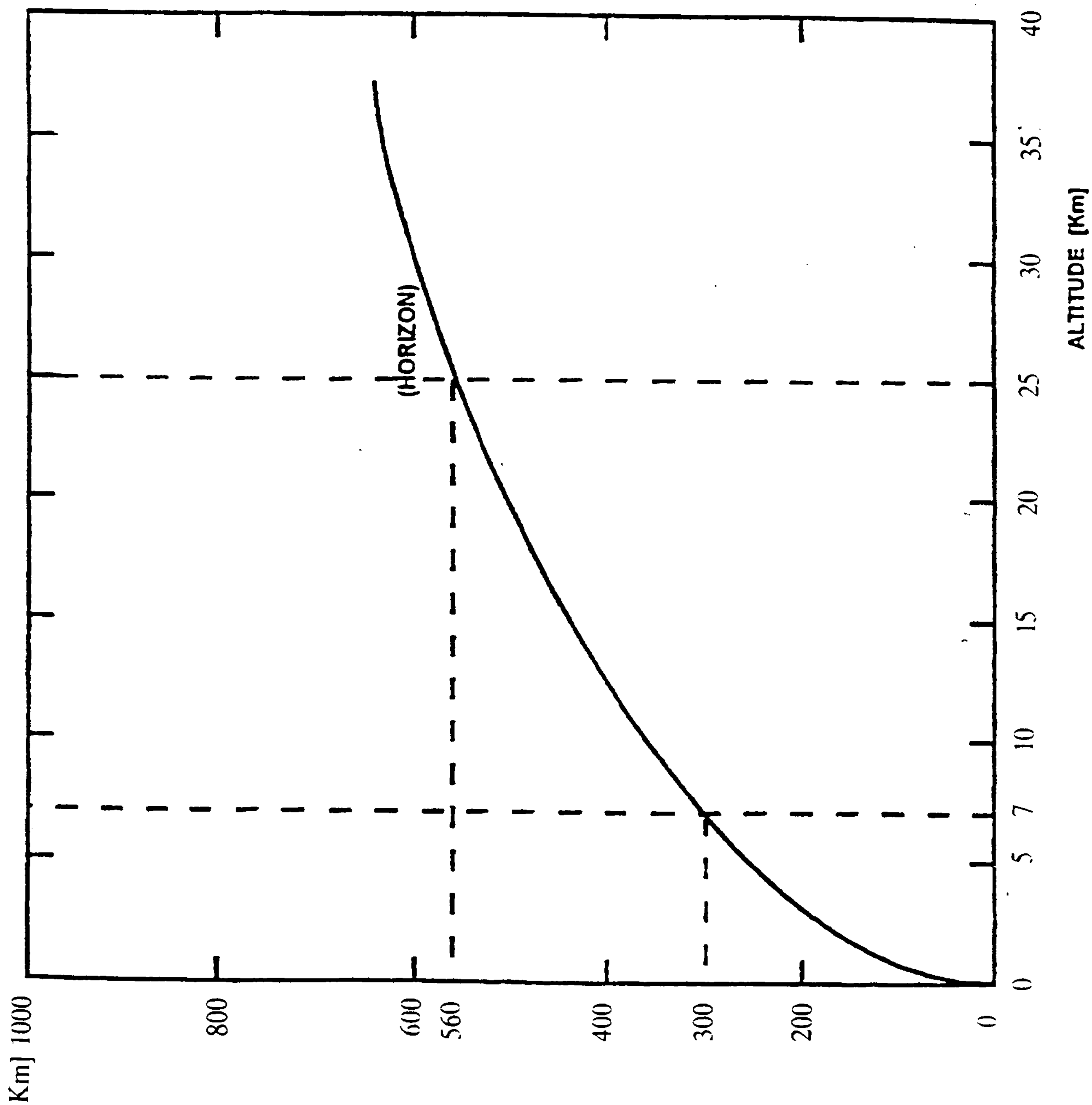

R [Km] 1000
800
600
560
400
300
200
0
(HORIZON)
ALTITUDE [Km]
0
5
7
10
15
20
25
30
35
40

Fig. 18

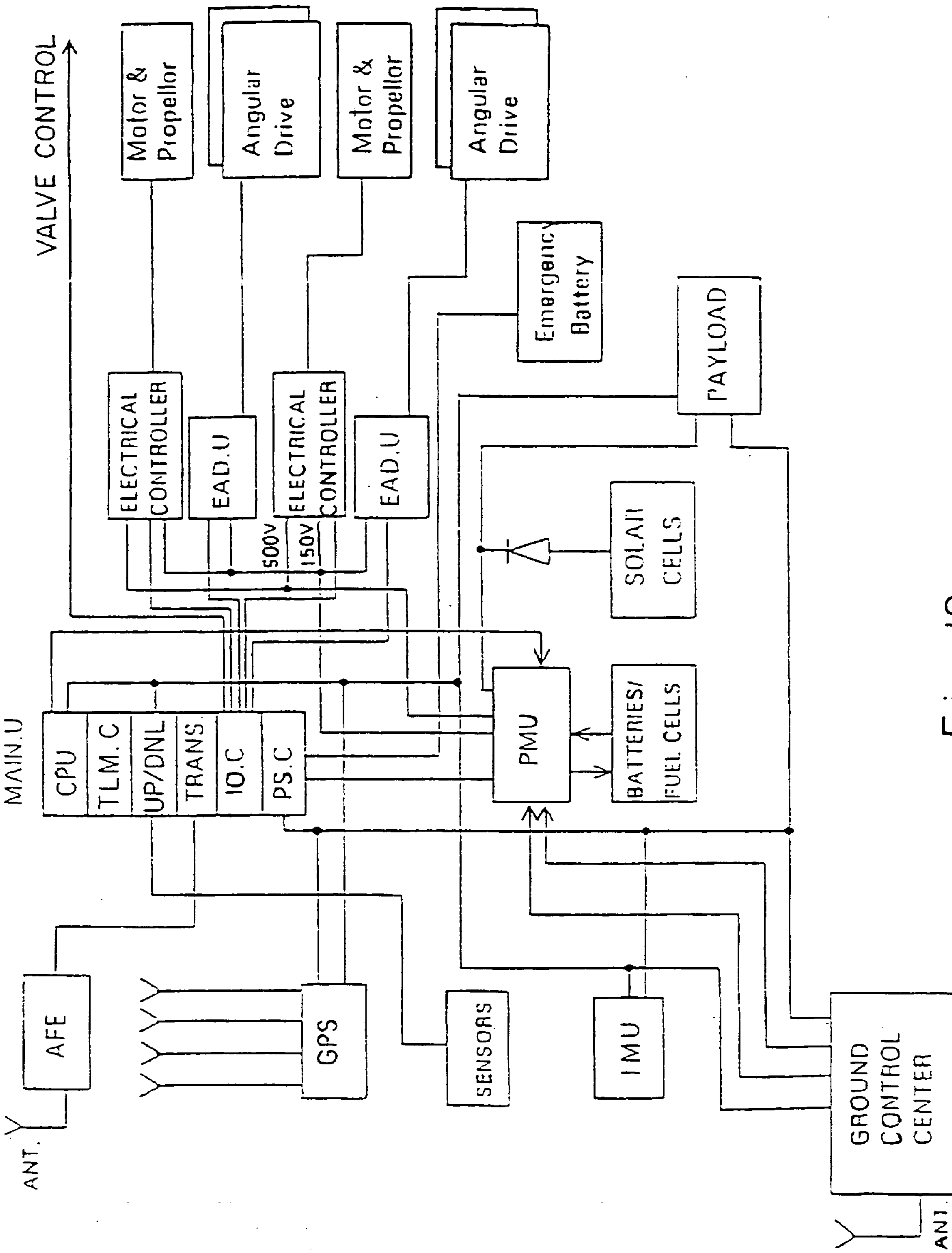

VALVE CONTROL
Motor & Propellor
Angular Drive
Motor & Propellor
Angular Drive
Emergency Battery
PAYLOAD
ELECTRICAL CONTROLLER
EAD.U
ELECTRICAL CONTROLLER
EAD.U
500V
150V
SOLAR CELLS
MAIN.U
CPU
TLM.C
UP/DNL
TRANS
IO.C
PS.C
PMU
BATTERIES/ FUEL CELLS
AFE
ANT.
GPS
SENSORS
IMU
GROUND CONTROL CENTER
ANT.

Fig. 19

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IL 96/00125

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04B7/185

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04B B64B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 082 995 A (MCNULTY) 17 March 1982 see the whole document ---	1-43
X	WO 95 04407 A (INTERNATIONAL MULTIMEDIA CORPORATION) 9 February 1995 see claims 1-136; figures 1-10 ---	1-43
A	US 4 995 572 A (PIASECKI) 26 February 1991 see column 1, line 45 - column 2, line 45; figures 1-5C -----	1-43

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
28 February 1997	17. 03. 97
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+ 31-70) 340-3016	Authorized officer Bischof, J-L

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/IL 96/00125

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2082995 A	17-03-82	NONE	
WO 9504407 A	09-02-95	AU 7365494 A	28-02-95
		BR 9407157 A	17-09-96
		CA 2168353 A	09-02-95
		CN 1132008 A	25-09-96
		DE 4495639 T	31-10-96
		EP 0711476 A	15-05-96
		FR 2712128 A	12-05-95
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		IT RM940510 A	30-01-95
		PL 313220 A	10-06-96
US 4995572 A	26-02-91	NONE	